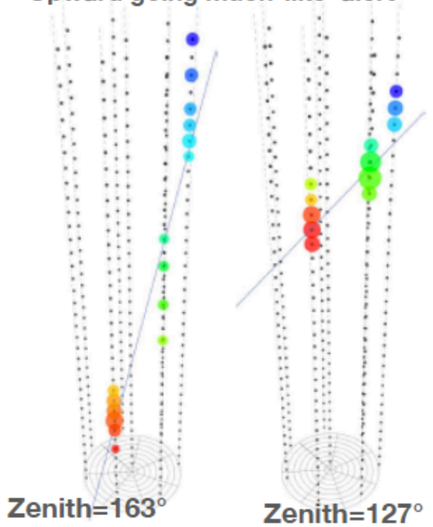
Multi-messenger and real-time astrophysics with the Baikal-GVD telescope

O.Suvorova for Baikal-GVD Collaboration

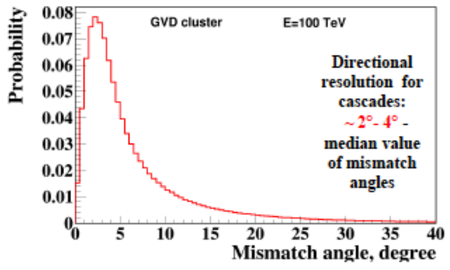
Quasi-online regime in alert performance

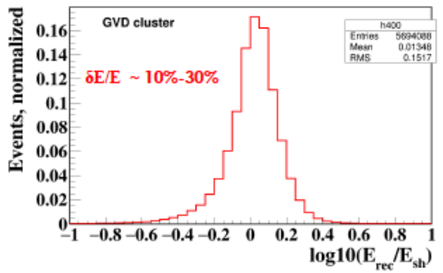
Publ.: Avrorin A.D. et al. , Astronomy Letter, Vol.47, N 2, 114 (2021)

Upward going muon-like alert

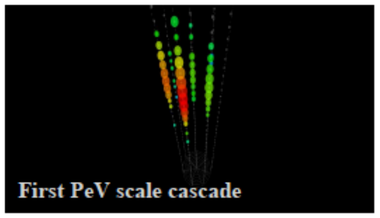


Fast algorithm of track reco in a single cluster events rejects a near horizon directions (<120°)
(see talks by G.Safronov, D.Zaborov)

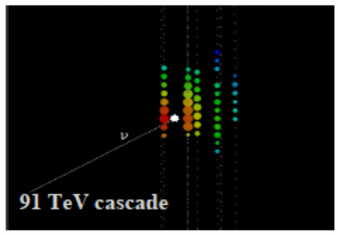




Downward going HE cascade-like alert



Upward going HE cascade-like alert

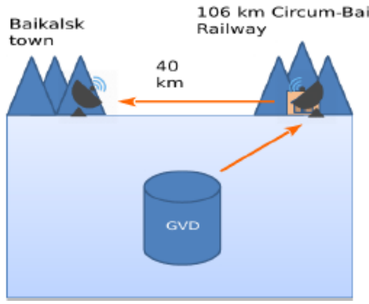


Cascades reco algorithm, selections and HE alerts - see talk by Zh.Dzhilkibaev

5

Data transmission:

- 40 Gb per cluster per day to shore
- 250 Mb/s 40 km radio channel to Baikalsk
- Raw data transferred to storage Dubna facility through Internet



Runtime ~ 12hours. Data performance takes of 3-5 hours

See talk by B. Shaybonov

GVD follow up of ANTARES (TAToO)

Since Dec 2018, in total of 48(-6) alerts have been analysed; 15 alerts in 2020 and 6 alerts in 2021

Repeated cascades in 3 alerts

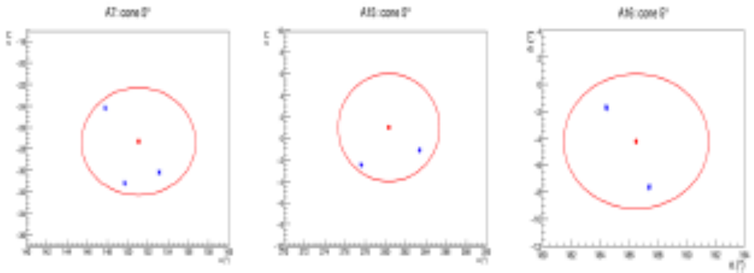
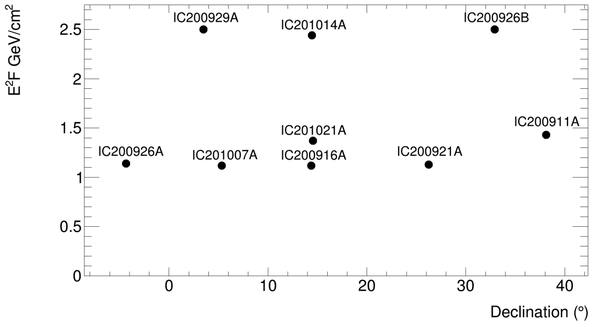


Figure 3: View in equatorial coordinates: circles of 5 degrees radius around the ANTARES alerts (red point in center) and the GVD reconstructed cascades (blue stars).

No prompt coincidence in time and direction was found with HE muon neutrino alerts

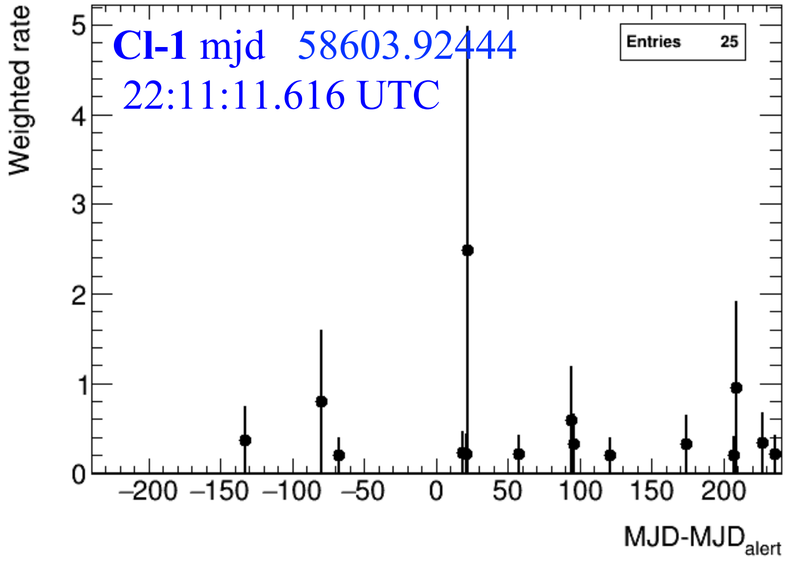
GVD follow up of IC astrotracks

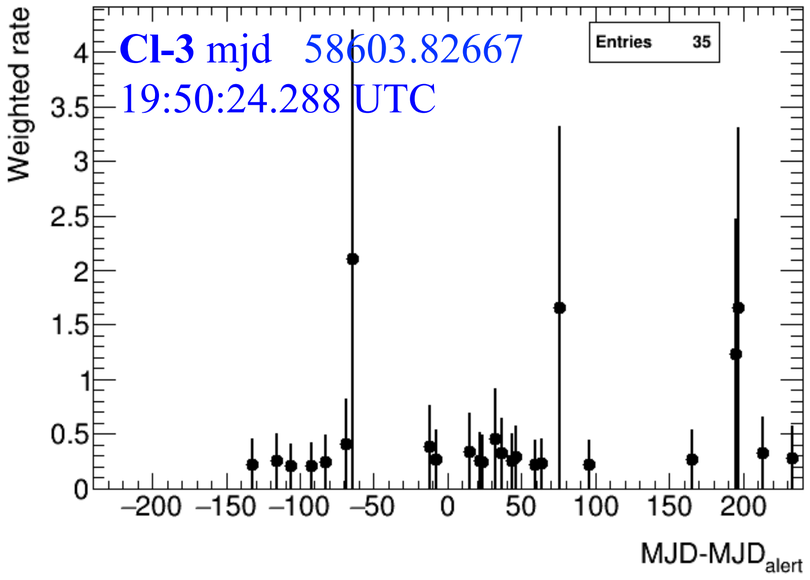


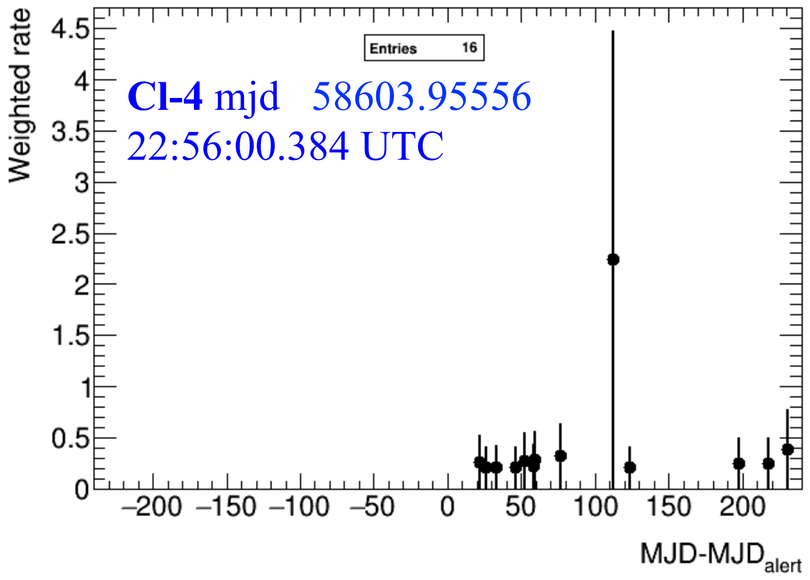
Starting from Sept 2020 Baikal-GVD follow **IC alerts (GCN) in fast regime**.
Assuming E^{-2} spectral behavior and equal fluence in all flavors, upper limits at 90% c.l. have been derived on the neutrino fluence from IC alerts in Fall 2020: **~1÷2 GeV cm^{-2}** for energy range **1TeV– 10PeV for ±12h interval**.

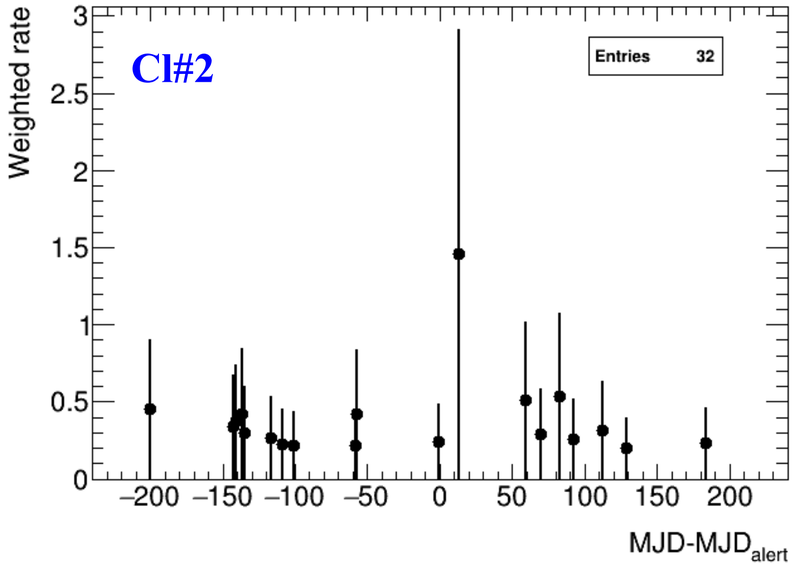
ZTF AT2019dsg : GVD cascades around MJD_{TDE}±200 days

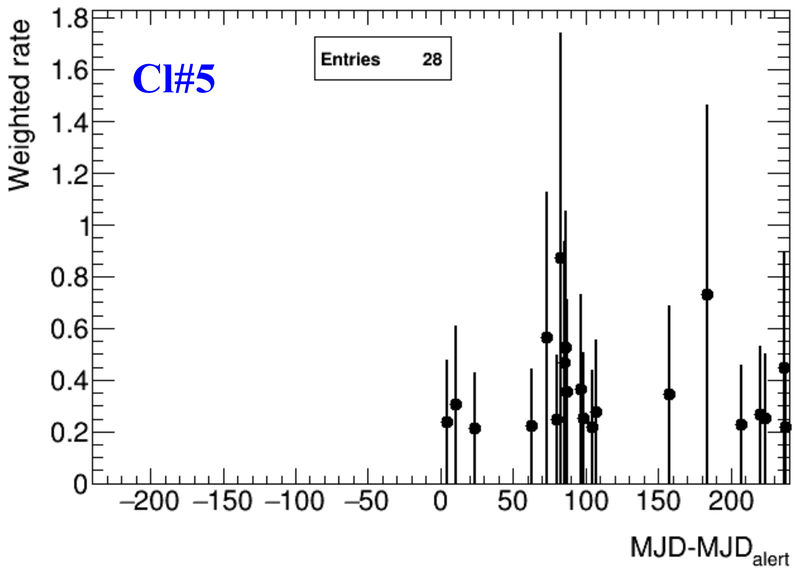
cone_5°around point "Decli=14.2°" and for bckg "RA=0°÷360°" step=10° ; Apr-2019-Feb2020











MJD_{TDE} 58582.9649074
11:09:28.000 UTC

$MJD_{triplet}$ 58603.(826/924/955)
MJD_{TDE}+21day

Level	5cls(<ra>)/+-12h	…/+-1h
Nobs/Nbkg	3/ 0.485	2/ 0.0286
p-val	0.0117	0.000397
sigma	2.26σ	3.35 σ

Very preliminary results

Magnetar SGR1935+2154: 28 Apr 2020

SGR **1935+2154: Ra = 293.75°; Dec = 21.54°**
CHIME/FRB observed radio burst**: 28.04.2020 14:34:33 GMT;** INTEGRAL discovery of FRB;
associated with SNR G57.2+0.8

Baikal-GVD: At burst time, the source was located 0 degrees below the horizon for GVD. Data of first 5 GVD clusters recorded in time window of ±24 hours around the burst time have been analyzed to search for neutrino events associated with burst.

For trigger $N_{hit}>9$ & $\psi<5°$
$P(n>=2, \mu=0.35) = 0.0487$ ➔ 1.97 σ

$E^2 F = n_{90\%} / Expos = 2.0\ 10^{-3}$ TeV/cm^2

Summary and Outlook

- Baikal-GVD aims to reach minutes in data transmission for online stream analysis and trigger HE alerts.
- No prompt coincidences were found **with ANTARES triggers and IC astrotracks.**
- **The UpL$^{90\%}$ on neutrino fluence towards IC alerts** estimates the GVD sensitivity to Northen sky astrophysical sources.
- ***The UpL$^{90\%}$ on neutrino fluence towards SGR1935+2154 was obtained at 90% c.l. as 2 GeV• cm^{-2}.***
- **First estimates on transients and further analysis for ZTF TDE of 2019 is developing.**
- ***GVD cooperation in MM investigations with groups of radio observatories RATAN, OVRO***

(see talk by Zh.Dzhilkibaev).